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TELEMEDICINE

Review and summary

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Introduction

Telemedicine, broadly defined, refers to medical communications via the telemedia. The rapid expansion of information technology has focused greater attention on telemedicine. Although a "normal" medical consultation on the telephone may fall into the category of telemedicine, the concept primarily refers to the interaction of telemedia, multimedia, computers, and TV/video technology for medical purposes.

Telemedicine is a general term referring to a wide range of specific applications which are usually named after a particular discipline, e.g. teleradiology, telepathology, teledermatology, telecardiology, telelogopedics, telepsychiatry, etc.

International development in telemedicine began in 1950s and accelerated during the 1970s. The United States, Canada, and Australia were early in developing telemedicine.

Teleradiology was introduced in Sweden in 1970, linking, Landskrona, Malmö, and Lund, and telepathology began in 1979 between Eksjö and Malmö. Images were transmitted using television technology. The transmission of radiology images through the telephone network was tested in Sweden in 1981 between Landskrona, Helsingborg, Malmö, and Lund.

With improvements in the capacity of the telephone network and the technological advancement of medical equipment, teleradiology progressed substantially during the 1980s. Early teleradiology links in Sweden were established between Bäckefors and Trollhättan and between Sveg and Östersund.

Need for telemedicine

The need for telemedicine can be described by looking at the areas of application and at the desired effects. Although not a comprehensive listing, the following needs represent some basic areas of application:

- consultations, among specialists
- consultations, between primary care (GPs) and hospital specialists
- on-call duty
- education, in-service training

- communications of referrals, laboratory and radiology reports
- increased quality of care
- increased level of service to patients
- increased efficiency of care
- applications in rehabilitation, care of the handicapped and elderly

It is hoped that future applications of telemedicine will promote improvements in the quality and efficiency of health care. This document presents several of the positive results as well as other results which have been reported in some areas. Generally, telemedicine means:

- that specialist knowledge becomes easily accessible and the use of these resources can become more efficient
- opportunities to increase the quality and safety of care and to increase the level of service to patients
- opportunities to give staff a better working environment and greater opportunities for professional development
- opportunities to increase efficiency in the management, communications, and distribution of images (e.g., radiology and pathology) and other medical data base information (e.g., referrals, laboratory reports, and radiology reports)
- opportunities for organisational and structural change in health care, e.g., by more efficient utilisation of specialists and greater accessibility to speciality knowledge by primary care
- opportunities for organizational and structural change in on-call duty, via increased co-operation among hospitals-hospitals, throughout the county council, region, and perhaps nationally with regard to the joint utilisation of certain super specialities

It should be noted that telemedicine is still in a very early phase of development and only a few applications are used routinely. It will take substantial development and assessment before the many applications of telemedicine become part of the daily routine in health care.

Surveying the interest in telemedicine

To study the interest in telemedicine, Spri sent a questionnaire to the 62 sections of the Swedish Medical Society in 1992. The questionnaire explored the interest among various disciplines in using telemedicine and the potential interest in engaging in development projects.

Responses were received from 25 of the 62 sections. The following 15 sections indicated a strong interest in telemedicine and in the following applications:

Surgery	X-ray images, dynamic image transfer
Pulmonary Medicine	X-ray images
Neurology	X-ray images, motion disorders via TV/video
Neurosurgery	X-ray images
Radiology	X-ray, CT, MRI images, etc.
Ear	X-ray and microscopic images
Paediatric Cardiology	Ultrasound images

Cytology	Microscopic images
Medical Genetics	Microscopic images, patient images
Pathology	Microscopic images
Physiology	ECG
Neurophysiology	EEG, EMG
Audiology	Hearing examinations
Dermatology	TV/video image transfer, documentation
Clinical Chemistry	Test results

Most of the remaining responses indicated an interest in monitoring developments in telemedicine. Several indicated interest in the various applications for electronic mail in health care.

Throughout 1993, Spri has observed an increased interest in telemedicine. In addition to the sections listed above, the fields of speech therapy and psychiatry have expressed interest in actively exploring the development of telemedicine applications.

Teleradiology

An important application of telemedicine is teleradiology, which, following an initial trial in the 1970s, was introduced in Sweden in the early 1980s. The desire to transmit radiology images for consultations is manifested by the high level of interest in this technology. During the first half of the 1980s, the capabilities of telemedia and medical equipment were such that transmission time was, in practice, too long and better image quality was asked for.

Recently, the increased accessibility to telemedia with transmission capacity of 64 kbit/sec (ISDN net), successful tests at even higher transmission speeds, and new type of equipment have meant that the technical prerequisites for teleradiology have improved substantially. Nearly 60 teleradiology units now exist in Sweden, making teleradiology the most diffused telemedical technology in Sweden. However, many of these are experimental or are being used in research and development projects. Currently, few organizations are linked for image transmission, which means that the technology is not widely used in daily clinical routines. For example, its use is sometimes limited to the presence of certain individuals in the organization.

Although it has diffused widely in Sweden, teleradiology is still considered to be an emerging technology. It is essential to be able to produce good quality images at a reasonable cost. The level of image quality depends on the particular application, and can vary substantially. A precise, final diagnosis often requires transmitting an image quality which is superior to that needed when a diagnosis is already established and the teleradiology consultations concerns the management and treatment of the patient (often emergency cases). These wide performance boundaries mean that the market is not homogeneous, but room exists for different types of equipment at different levels of performance and price. Other paths of development include integrating teleradiology systems with computer networks, image archives, and radiology information systems.

As mentioned, teleradiology is still considered to be somewhat experimental, and this technology has not been widely integrated into normal organizational structure. As a result, teleradiology has not been fully assessed in clinical environment. Consequently, planners and decision-makers hesitate to invest in the technology since they are uncertain about the clinical and economic effects, and the structural opportunities. The lack of standardization related to image transmission limits communication to between units from the same manufacturer, which slows development.

A list of installations showing the diffusion of teleradiology in Sweden appears at the end of this review and summary.

Development

There is a substantial interest in testing and evaluating a variety of applications for telemedicine. Projects related to diverse field of telemedical applications are under way in Sweden and Internationally. Applications where research and development projects are under way or may be expected include:

- dermatology
- handicap services
- clinical physiology
- clinical neurophysiology
- conference/rounds
- speech training
- odontology
- pathology
- psychiatry
- rehabilitation
- referrals, lab and radiology reports
- education/in service training
- care of the elderly
- eye
- ear-nose-throat

Experiences with telemedicine

The following section briefly summarizes some plans and experiences of telemedical developments as reported by the different authors contributed to this report.

Experience with teleradiology

In a pilot projects in teleradiology between **Östhammar and Uppsala University Hospital**, 32 emergent or partly emergent radiology examinations were transmitted, mainly skeletal and lung images. Image quality of small skeletal parts was consistently good. Lung and abdominal diagnostics were performed without problem. With few exceptions, it took about 45 minutes from the image transmission commenced in Östhammar to establish diagnosis. The results suggest a need in primary care to have emergency X-ray examinations interpreted by an

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Increasingly, the user of telemedicine use the ISDN (Integrated Services Digital Network) with a transmission capacity of 64,000 bit/sec or multiples of that capacity. The cost of connecting to the ISDN in a city in Sweden is SEK 6,000 plus a quarterly charge of about SEK 1,500. The minute charge for using ISDN (per multiple) is the same as for a regular telephone.

International

Telemedicine, e.g., radiology and emergency ECG (from ambulances), has been established (but in limited use) in United States since the first half of the 1980s. The use of teleradiology in the United States involves image transmission from mobile diagnostic units as CT and MRI to contracted hospitals for "back up" and "second opinions" with regard to speciality diagnostics and on-call duty where the on-call physician has access to a teleradiology unit at home. Hospital groups and chains in the United States have been installing teleradiology to link together their hospitals. In this way, all member hospitals can offer the high level of speciality competence which may otherwise exist at only one facility.

The development and application of telemedicine in Europe has progressed considerably slower than in the United States. A probable reason is that the economic incentives in the area mentioned above are greater in the United States. European development projects supported by EC, and the general increase in interest for telemedicine, has accelerated the pace of development in Europe in recent years.

One example of the increasing interest in telemedicine in Europe is the First European Symposium on Telepathology, which was held in Heidelberg in 1992. The second symposium is planned for 1994 in Paris.

Teleradiology is available in all Nordic countries. As noted earlier, there are approximately sixty units in Sweden, ten in Finland, four in Denmark, and two in Iceland.

Since 1988, the Norwegian national telephone company has invested in a co-ordinated development program for telemedicine in Tromsø. This program has an annual budget of approximately 10 million Norwegian crowns. The telemedicine project in Tromsø and northern Norway includes:

- teledermatology
- teleechocardiology
- teleendoscopy
- telepathology
- telepsychiatry
- teleradiology
- test reports
- standardization
- video conferences/education

These efforts make Norway a pioneer among the Nordic countries with regard to a systematic and co-ordinated research and development in the area of telemedicine. In addition, Norway has recently been involved in the construction of a national Center for Medical Informatics. This effort is located in Trondheim.

Standardization

A problem affecting the application and diffusion of telemedicine, e.g., image transmission in radiology and pathology, is that an international image standard does not exist. Therefore, equipment at each end of the transmission link must be from the same manufacturer. The result is that many providers are waiting to invest in equipment until standards have been established.

In the United States, the ACR-NEMA (American College of Radiology - National Electrical Manufacturer's Association) has been working for 11 years to establish standards for radiology images. They have published two versions, 1985 and 1988. An significantly expanded version is expected in the summer of 1994.

The CEN standardization body in Europe began medical informatics standardization work in 1990. This effort is divided among the following seven work groups:

- Healthcare information modelling and medical records
- Healthcare terminology, semantics, and knowledge bases
- Healthcare communications and messages
- Medical imaging and multimedia
- Medical devices
- Healthcare security and privacy, quality and safety
- Interconnected medical devices (e.g. patient cards)

In Sweden, HSS (Health Care Standardization) has established corresponding work groups to monitor and influence the European standardization work, and to inform Swedish health services about these developments.

Concluding observations

Telemedicine remains in an early development phase - particularly if we look at practical clinical applications. Teleradiology is the application which is coming closest to routine use in Sweden and internationally. Teleradiology has been in routine use in the United States in many years. To facilitate urgent development and practical application, and the diffusion of this technology, it is important to give telemedical projects a wide berth. This means, in addition to development and testing of functional performance (which certainly is a basic condition), that projects should include activities which allow telemedicine to be tested in the practical clinical routines of a health care organization. This would make it possible to assess the broad medical, organizational, structural, and economic impact of the technology. These findings should provide a more solid basis for making decisions to those who are planning to invest in telemedicine.

Applications and interest in telemedicine within primary care is increasing. Therefore, it seems to be essential, not least for cost reasons, to explore opportunities for a common future strategy and to develop a system, a "common telemedicine terminal", which serves multiple telemedicine functions in primary care. Examples of such applications may be teledermatology, teleradiology, telelogopedics, telepsychiatry, and management of referrals, test reports (perhaps including microscope images), and radiology reports. Further development of the

computerized medical record in primary care should adapt to a similar future perspective. One interesting prospect would be to use telemedicine to make on-call duties better and more efficient. Improvements could include, for example, access to specialists' knowledge and the efficient, co-operative use of this resource. It is essential to promote and try out the development of such applications.

A major obstacle toward developing and applying telemedicine, not least organizationally and structurally, is the lack of a uniform international data standard, e.g., for medical images and biosignals. In practice, for cost reasons, this means that communication is limited to equipment made by the same manufacturer. It is therefore essential to accelerate international standardization efforts.

Diffusion of teleradiology

Teleradiology is the application of telemedicine which has diffused most widely in Sweden. In October, 1993, the following hospitals and health services units in Sweden were equipped for teleradiology. Since teleradiology somewhat remains in the development phase, several of the installations listed below are involved in research and development projects:

Hospital / units	Year	Industry	Location
Akademiska, Uppsala	1990	IMTEC	Dept of radiology
Gävle	1991	IMTEC	Dept of radiology
Helsingborg	1993	IMTEC	Dept of radiology
Landskrona	1993	IMTEC	Dept of radiology
Leksand	1993	IMTEC	Primary care (GPs) centre
Lund	1988	IMTEC	Dept of radiology
Mora	1993	IMTEC	Dept of radiology
Sahlgrenska, Gothenburg	1993	IMTEC	Dept of radiology
Skövde	1993	IMTEC	Dept of radiology
Trelleborg	1993	IMTEC	Dept of radiology
Ystad	1988	IMTEC	Dept of radiology
Östhammar	1990	IMTEC	Primary care (GPs) centre
Akademiska, Uppsala	1992	Photophone	Neurosurgery
Halmstad	1991	Photophone	Acute surgery
Halmstad	1991	Photophone	Orthopaedic radiology
Karolinska, Stockholm	1990	Photophone	Acute radiology
Karolinska, Stockholm	1990	Photophone	Neuroradiology
Karolinska, Stockholm	1990	Photophone	Neurosurgery
Lindesberg	1992	Photophone	Dept of radiology
Linköping	1991	Photophone	Odont. radiology
Löwenströmska	1990	Photophone	Dept of radiology
Mora	1993	Photophone	Dept of radiology
Norrköping	1991	Photophone	Odont. radiology
Norrköping, odont	1992	Photophone	Odont. radiology
Norsjö Källan	1992	Photophone	
Sabbatsberg	1990	Photophone	Dept of radiology
St Göran	1992	Photophone	Paediatric radiology
Sälen/Särna	1993	Photophone	
Söderhamn	1992	Photophone	Dept of radiology
Södersjukhuset	1990	Photophone	Neuroradiology

Visby	1990	Photophone	Dept of radiology
Vällingby clinic	1993	Photophone	Dermatology
Örebro	1992	Photophone	Intensive care unit
Östersund	1990	Photophone	
Alingsås	1992	SECTRA	Dept of radiology
Backe	1991	SECTRA	Primary care (GPs) centre
Frösön	1991	SECTRA	Primary care (GPs) centre
Funäsdalen	1991	SECTRA	Primary care (GPs) centre
Gäddede	1991	SECTRA	Primary care (GPs) centre
Gällivare	1992	SECTRA	Dept of radiology
Gävle	1991	SECTRA	Dept of radiology
Karlskoga	1990	SECTRA	Dept of radiology
Karlskrona	1993	SECTRA	Dept of radiology
Lund	1993	SECTRA	Thorax surgery
Mjölby	1991	SECTRA	Dept of radiology
Motala	1991	SECTRA	Dept of radiology
Pajala	1992	SECTRA	Primary care (GPs) centre
Sahlgrenska, Gothenburg	1992	SECTRA	Neuroradiology
Sahlgrenska, Gothenburg	1992	SECTRA	Neurosurgery
Sandviken	1991	SECTRA	Dept of radiology
Strömsund	1991	SECTRA	Primary care (GPs) centre
Sveg	1991	SECTRA	Primary care (GPs) centre
Umeå	1993	SECTRA	Dept of radiology
Åre	1992	SECTRA	Primary care (GPs) centre
Örebro	1990	SECTRA	Dept of radiology
Östersund	1991	SECTRA	Dept of radiology
Östersund	1992	SECTRA	Dept of orthopaedic
Östersund	1992	SECTRA	Dept of radiology
Östersund	1992	SECTRA	Emergency dept
Malmö	1992	Siemens	Dept of radiology

Sweden's approximately 60 teleradiology units means a density of about one teleradiology unit per 150,000 population. This probably ranks Sweden as the second most densely served country in terms of teleradiology. The USA is first with one teleradiology unit per 100,000 population.